

Composition of Hydrates

Lab 11

Text reference: Chapter 7, pp. 154–159

Pre-Lab Discussion

Hydrates are ionic compounds (salts) that have a definite amount of water (water of hydration) as part of their structure. The water is chemically combined with the salt in a definite ratio. Ratios vary in different hydrates but are specific for any given hydrate.

The formula of a hydrate is represented in a special manner. The hydrate of copper sulfate in this experiment has the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$. The unit formula for the salt appears first, and the water formula is last. The raised dot means that the water is loosely bonded to the salt. The coefficient x stands for the number of molecules of water bonded to one unit of salt. This special formula, like all other formulas, illustrates the law of definite composition.

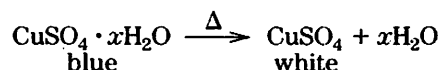
When hydrates are heated, the "water of hydration" is released as vapor. The remaining solid is known as the *anhydrous* salt. The general reaction for heating a hydrate is:



The percent of water in a hydrate can be found experimentally by accurately determining the mass of the hydrate and the mass of the anhydrous salt. The difference in mass is due to the water lost by the hydrate. The percentage of water in the original hydrate can easily be calculated:

$$\text{percent H}_2\text{O} = \frac{\text{mass H}_2\text{O}}{\text{mass hydrate}} \times 100$$

In this experiment, as was mentioned, a hydrate of copper sulfate will be studied ($\text{CuSO}_4 \cdot x\text{H}_2\text{O}$). The change from hydrate to anhydrous salt is accompanied by a change in color:



This investigation should aid in the understanding of the formulas and composition of hydrates and the law of definite composition.

Purpose

Determine the percentage of water in a hydrate.

Equipment

evaporating dish, porcelain
crucible tongs
microspatula
laboratory balance
ring stand

iron ring
wire gauze
laboratory burner
safety goggles
lab apron or coat

Materials

copper sulfate hydrate, $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$

Safety



Do not touch a hot evaporating dish with your hands. Tie back long hair and secure loose clothing when working around an open flame. Note the caution alert symbols here and beside certain steps in the "Procedure." Refer to page xi to review the special precautions associated with each symbol.

Be sure to wear a lab apron or coat and safety goggles when working in the lab.

Procedure

1. Prepare the setup shown in Figure 11-1.

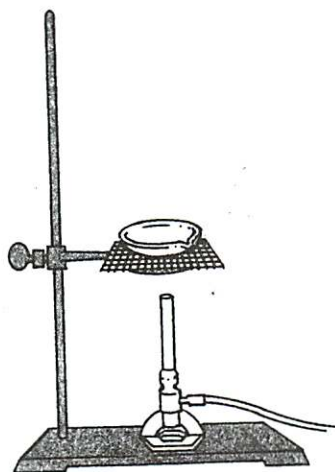


Figure 11-1

2. Heat the dish with the hottest part of the flame for 3 minutes.
3. Using crucible tongs, remove the evaporating dish from the apparatus. Place it on an insulated pad and allow it to cool for several minutes.
4. Find the mass of the evaporating dish to ± 0.01 g. Record the mass in the Observations and Data section.
5. With the evaporating dish on the balance, measure into it exactly 2.00 g of copper sulfate hydrate. Record the data below.
6. Place the evaporating dish + hydrate on the wire gauze. *Gently* heat the dish by moving the burner back and forth around the base. Increase the heat gradually. Avoid any popping and spattering.
7. Heat strongly for 5 minutes or until the blue color has disappeared. During heating, a microspatula may be used to "spread" the solid and break up any "caked" portions of the hydrate. Be careful not to pick up any of the solid on the microspatula. If the edges of the solid appear to be turning brown, remove the heat momentarily and resume heating at a gentler rate.



Name _____

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8. Allow the evaporating dish to cool for about a minute. *Immediately* find the mass of the dish + anhydrous salt, and record the data below.

Observations and Data

- a. Mass of evaporating dish _____ g
- b. Mass of evaporating dish + hydrate _____ g
- c. Mass of evaporating dish + anhydrous salt _____ g

Calculations

1. Find the mass of the hydrate used ($b - a$).
2. Find the mass of the water lost ($b - c$).
3. Find the percentage of water in the hydrate:

$$\text{percent H}_2\text{O} = \frac{\text{mass water}}{\text{mass hydrate}} \times 100$$

Conclusions and Questions

1. The true value for the percentage of water in this hydrate is 36.0%. What is your experimental error?

2. Why must you allow the evaporating dish to cool before measuring its mass?

3. Why must you measure the mass of the anhydrous salt immediately upon cooling?

Show all work w/
the appropriate units.

4. Explain how your class's results in this experiment support the law of definite composition.

5. Given the true mole masses of CuSO_4 (160 g) and H_2O (18 g), how could you find the exact formula of the hydrate from your experimental data? That is, how could you find the value of x in the formula $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$?

6 What percentage of water is found in $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$?

7 A 5.0 g sample of a hydrate of BaCl_2 was heated, and only 4.3 g of the anhydrous salt remained. What percentage of water was in the hydrate?

8 A 2.5 g sample of a hydrate of $\text{Ca}(\text{NO}_3)_2$ was heated, and only 1.7 g of the anhydrous salt remained. What percentage of water was in the hydrate?

9 A 3.0 g sample of $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ is heated to constant mass. How much anhydrous salt remains?

10 A 5.0 g sample of $\text{Cu}(\text{NO}_3)_2 \cdot n\text{H}_2\text{O}$ is heated, and 3.9 g of the anhydrous salt remains. What is the value of n ?
